# EVALUATION OF A SMALL, IN-FIELD RUNOFF COLLECTOR

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**Abstract.** Increased environmental concern about surface water pollution has heightened the need for small, in-field runoff collectors to assess the impact of land management practices without altering the landscape. We modified a surface flow sampler designed for sheet flow in Coastal Plain soils. Modifications were made to accommodate steep slopes (3 to 15%), large flow rates, and channelized flow which are common in the Southern Piedmont. The runoff collector consists of two sample splitters (10x and 100x) and two sample collectors. Runoff collector performance was evaluated in the laboratory to determine percent flow captured by 10x and 100x splitters relative to flow rate and slope. Average flow captured on a 5% slope was 10.3% for 10x and 1.8% for the 100x. When the slope was increased to 12% the percent flow capture also increased slightly, 10.4% for 10x and 2.3% fir 100x. It was determined that the small, in-field runoff collector captures runoff volumes at specific rates at fairly consistent ratios.

## INTRODUCTION

Increased environmental concern about nutrient loadings in runoff and surface water has heightened the need for evaluation of management practices at the field scale. A better understanding of nutrient concentrations in runoff from fields under various management practices will assist policy makers in developing realistic guidelines and land managers in optimizing nutrient use. Nutrient concentrations vary with landscape type, position, and use. Several runoff studies have used sophisticated instrumentation to measure and sample runoff from pastures at the field scale (Vervoort et al. 1998; Moore et al. 1998). While these approaches give detailed information on runoff, they are often too costly and imposing to use when working with farmers and with small budgets. In another runoff study Ulen (1997) collected runoff from cropped fields using collection troughs at the bottom of delineated slopes (Gerlach, 1967). Runoff water was pumped out and collected from a protected vessel on a weekly basis. Though less imposing in size and cost, this method may result in added denudation of the landscape where slopes tend to be steeper as is the case in the Southern Piedmont.

The high cost of instrumenting watersheds with full-size, runoff collection systems limits the number of sites that can be evaluated. Thus, there is a need for small in-field runoff collectors to assess nutrient migration at the field scale on various land management systems. These runoff collectors should be economical, unobtrusive, and require little alteration of the landscape. In addition these runoff collectors should be able to measure intermittent runoff and/or rill runoff. Sheridan et al.(1996) designed a low-impact flow event (LIFE) sampler that causes minimal disturbance and has minimal cost. The LIFE sampler was designed to quantify and qualify nutrient concentrations in runoff flowing through riparian buffers in the Coastal Plain, where slopes are gentle and sheet flow is likely. We modified the LIFE sampler to accommodate steep slopes (3 to 15%), large flow rates, and channelized flow, which are common in the Southern Piedmont.

## OBJECTIVES

In this work we describe the modified sampler and present the results of a laboratory study to evaluate the effect of flow rate and slope on the performance of the small in-field runoff collector. The specific objectives of the laboratory study were: to 1) determine percent flow captured by 10x and 100x splitters relative to flow rate, and 2) determine flow captured by 10x and 100x splitters for typical slopes (5% and 12%) in the Southern Piedmont.

## DESCRIPTION OF RUNOFF COLLECTOR

### Runoff Collector

The runoff collector is approximately 0.3 m x 1.2 m and consists of two sets of sample splitters (10 splitters for each set) with a collection port for each of the sets (Fig.1). It is made of 16 gauge stainless steel on the bottom and 20 gauge stainless steel for the splitters and cover. The stainless steel body sits on a ½ x ½ x 1/16 inch stainless steel angle iron frame (stabilizing frame) which extends out 2.5 cm from the sides (Fig. 1). These extensions have eyelets (leveling eye) to accommodate threaded rods which are cemented into the earth at least 45 cm and project upward. Nuts are placed on the top of the eyelets and are used to level the runoff collector laterally and to allow the collector slope to be adjusted equal to land slope. The frame includes angle irons on the perimeter as well as two additional angle irons underneath splitters which are perpendicular to the flow direction. The latter angle irons provide rigidity to prevent warping. Fabrication specifications were made to ensure that collectors remained stiff and level.

Water flows into the up-hill interface of the collector (Fig. 1), encounters a fluted bar which builds up hydraulic head until it rises to the bottom of the notches (one notch for each splitter). Water then flows through notches and into the first set of ten splitters at equal rates.

One tenth of the flow enters through the 10x port and is collected in the 10x holding tank (Fig. 2). Eight tenths flow out and away from the collector. The remaining tenth flows into the second chamber (100x), encounters a second fluted bar and is again split into ten parts.

One hundredth flows through the 100x port into the 100x holding tank. The remaining water flows out the back of the collector into the field.

### Holding and Collection Tanks

Both the holding tank and the collection tank are made of polyvinyl chloride irrigation pipe. Holding tanks are connected at the end of both the10x port and the100x port (Fig. 2). Tank volume was determined by the amount of runoff expected. The exterior tank (holding tank) acts as a protector and stabilizer. It is 20.3 cm in diameter and approximately 61 cm deep. On the bottom of each of the tanks are flat caps that have been glued into place. The flat cap placed on the bottom exterior of the holding tank leaves a lip which acts as a barb helping to secure the tank in the ground.

Inside the holding tank is a removable collection tank which sits on top of approximately 5 cm of gravel. The collection tanks are 15.2 cm in diameter and 40 cm in height (7.26 L). Samples are only taken from the

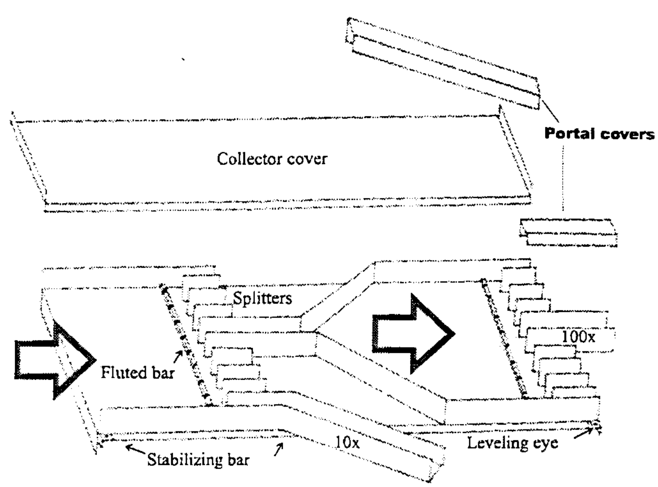


**Fig. 1. Three-dimensional view of runoff collector.**

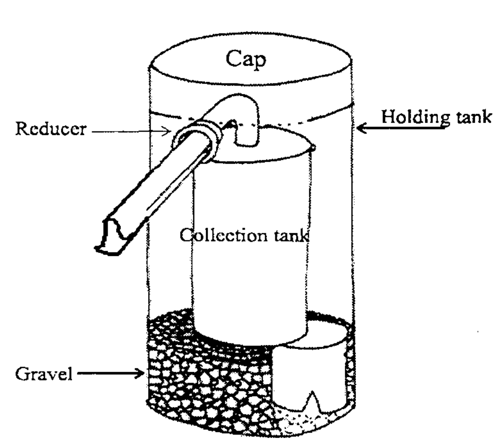


**Figure 2. Cross-sectional view of holding tank.**

removable collection tank which can be easily cleaned after each sampling event.

The main modifications made with respect to the LIFE sampler are the fluted bar, removal of the baffle, addition of a leveling system, combining 10x and 100x in one system, stainless steel fabrication, and the in-ground collection system with removable collection tank.

In the Southern Piedmont concentrated flow or rill flow of runoff is common. The fluted bar converts rill flow into sheet flow thus allowing the splitters to be more accurate. Runoff collectors have to be level laterally if the splitters are to be effective. Level surfaces are difficult to locate in pastures and fields especially in the Southern Piedmont where slopes are often concave or convex. The leveling system allows for lateral leveling while maintaining the natural longitudinal slope. The in-ground collection system with removable collection tank, minimized the area taken out of production and made it easier to measure sample volume, collect the sample and clean the collector.

## METHODS

Runoff collectors were set up in a laboratory on 5% and 12% slopes to determine their effectiveness at splitting and capturing ten percent (10x) and one percent (100x) of the flow encountered. An even-flow distributor (not shown) controlled flow distribution entering into the collector at flow rates between 1.4 and 5.2 L $min^{-1}$. Because it was difficult to maintain exact flow rates due to pressure variations in the water line, flow rates were measured before and after each collection event. Assuming an average capture area of 9 $m^2$, (0.3m x 30m slope length ) these flow rates represent runoff rates of 0.16 to 0.58 L $m^{-2}$ $min^{-1}$, which are values observed during winter in the Southern Piedmont (Georgia Automated Environmental Monitoring Network, UGA).

Calibrations for six runoff collectors were run for three minutes with three replications, for three groups of flow rates (1 to 2, 2 to 3.5, and 3.5 to 5.5 L $min^{-1}$) at two slopes. Averages and sample standard deviations were calculated for each slope and flow rate group.

## RESULTS AND DISCUSSION

The average flow captured by the 10x splitter for flow rates from 3.5 to 5.5 L $min^{-1}$ was 10.2% (std dev=0.6) for the 5% slope, and 9.9% (std dev=0.2) for the 12% slope (Table 1). The average flow captured by the 10x splitter for flow rates between 2 and 3.5 L $min^{-1}$ was 9.8 % (std dev=1.3 and 0.6, respectively) for both the 5% and 12% slopes. In general, low flow rates (1 to 2 L min-1) rates tended to be further away from the expected 10% mark, and as flow increased, capture moved closer to 10 % while the standard deviations decreased.

The average flow captured by the 100x splitter for flow rates from 3 to 5.5 L $min^{-1}$ was 2.2% (std dev=0.3) for the 5% slope, and 1.9% (std dev=1.3) for the 12% slope (Table 1). The average flow captured by the 100x splitter for flow rates between 2 and 3.5 L $min^{-1}$ was 1.7 % (std dev=0.6) for the 5% slope, and 2.4% (std dev=0.5) for the 12% slope. In general, the percent capture was relatively consistent across all flow rates measured. Percent capture by the 10x and 100x splitter was not affected by slope or flow rate.

These results show that the 10X splitter had percent captures close to the expected values, while the 100X splitter had percent captures that were about double what

**Table 1. Effect of flow rate and percent slope on percent flow captured by 10x and 100x portals of small, in-field runoff collector.**

| Flow rate (L $min^{-1}$ ) | 12% Slope | | | | 5% Slope | | | |
|---|---|---|---|---|---|---|---|---|
| | 10x | | 100x | | 10x | | 100x | |
| | % Captured | Std dev | % Captured | Std dev | % Captured | Std dev | % Captured | Std dev |
| **3.5 to 5.5** | 9.9 | 1.0 | 1.9 | 1.3 | 10.2 | 0.6 | 2.2 | 0.7 |
| **2.0 to 3.5** | 9.8 | 0.6 | 2.4 | 0.5 | 9.8 | 1.3 | 1.7 | 0.6 |
| **1.0 to 2.0** | 11.6 | 1.1 | 2.4 | 1.0 | 10.9 | 0.6 | 1.5 | 0.3 |
| **Average** | 10.4 | | 2.3 | | 10.3 | | 1.8 | |

was expected. We believe this excess capture was due to a slight concave warping of the collector floor just before the 100X splitter. Therefore, the runoff collectors should be calibrated prior to installation in the field.

## CONCLUSIONS

Under laboratory conditions the small, in-field runoff collector captures runoff for specific flow rates at fairly consistent ratios. Thus, it is possible to compute runoff volumes from the amounts captured in the collector if contributing area is known. Use of this runoff collector will be helpful in furthering our knowledge of nutrient, pesticide, microorganism, and sediment migration from fields into streams. In calibrating the runoff collectors it was evident that manufacturing inconsistencies play a major role in the standard deviation that was present. More stringent criteria placed on the manufacturer would result in lower standard deviations.

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